A Macro Validation Dataset for U.S. Hurricane Models

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Abstract

Public and regulatory acceptance of catastrophe models has been hampered by the complexity and proprietary nature of the models. The outside user is generally dependent on the modeler to demonstrate the validity and reasonableness of model results. Accordingly, we have developed a dataset permitting macro validation – one that would allow a lay person to compare the overall results of a hurricane model to an historical record.

The macro validation dataset consists of the aggregate insured losses from hurricanes affecting the continental United States from 1900 through 1999. The historical losses in each county have been "trended" – adjusted from the conditions at the time to those existing today. The trending reflects not only estimated changes in price levels, but also estimated changes in the value of the stock of properties and contents, and changes in the insurance system. Our work extends and improves upon similar work by Landsea and Pielke (1998), published by the American Meteorological Society.

The paper describes the construction of the validation dataset and summarizes the resulting size of loss distributions by event, state and county. It also provides tables summarizing key statistics about all hurricanes affecting the United States (and Puerto Rico, the U.S. Virgin Islands and Bermuda) during the 20th century. Finally, we compare summary statistics from the dataset to the results of a hypothetical probabilistic hurricane model.

I. INTRODUCTION

Hurricane Andrew in 1992 heightened the concern among property insurers and reinsurers about the potential for losses from natural catastrophes. This heightened concern spread beyond hurricanes to other perils with the Northridge earthquake in 1994, and several major winter snowstorms and tornadoes during the nineties. Major catastrophes outside the U.S. during this time have also helped keep catastrophe issues in the forefront for property insurers and reinsurers worldwide.

Since natural catastrophes are infrequent, traditional actuarial pricing methods are of limited value. Actuaries are accustomed to estimating rate adequacy by adjusting a body of historical insurance premium and loss experience to reflect the anticipated future environment. For property insurance, this typically involves a projection using three to six years of recent, mature experience. Prior to hurricane Andrew, the actuarial literature suggested using a thirty-year experience period for measuring excess wind loads in property insurance ratemaking.

When extreme events in a particular region are expected to happen only once every hundred years or more, alternative approaches are clearly required. This is true whether the objective is to measure expected losses for rating purposes or probable maximum losses[1] for risk and capital management purposes. For catastrophe risk management, probabilistic computer simulation models have been developed as such an alternative. These models incorporate longer-term historical data about the physical events as well as engineering knowledge about their destructive potential. Insurers, reinsurers and rating agencies have generally accepted use of the models to project losses.

The models and their use as a ratemaking tool have not been free from controversy. Some insurance regulators have rejected their use in rate filings, citing the difficulty of verifying the model results. Regulators have also cited extreme rate indications and inconsistent results between competing models as a basis of their rejection. Despite these issues, the use of models continues to increase because they provide the most comprehensive use of available data to measure the costs and risks of catastrophes. In response, regulators in Florida and Louisiana have set up formal processes for evaluating catastrophe models.

Model Validation

Fundamentally, all catastrophe models proceed along the same analytical path. First, the key scientific parameters describing a specific historical or hypothetical event are determined. The models then estimate the incidence of damaging forces to property from that event. Finally, the resulting property damage and insured loss are

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[1] The probable maximum loss, or PML, is the loss amount that is estimated to be exceeded with a specific probability, for example 1% (or exceeded once within a specified return period, for example 100 years), resulting from one or more causes of loss affecting a portfolio of properties.

estimated based on the characteristics of the structure and the policy terms. More specifically, a probabilistic hurricane model contains the following four basic steps.

1. Assess the likelihood of events of various sizes, intensities and paths
2. Estimate the wind speeds at specific locations affected by each event
3. Estimate the damage to property, given the estimated wind speeds
4. Estimate the insured losses, given the damages.

A probabilistic hurricane model contains a comprehensive set of hypothetical events, each with an assigned probability. The event set is intended to provide a representative sampling of possible hurricane paths, sizes and intensities. Thus, it produces an estimate of the range of possible insured losses for any relevant location or geographical area. The statistical distribution of insured losses occurring at a particular location is reflective of the convolution of the four steps cited above.

At each of these steps, local validation is performed by comparing the model's predictions for a particular parameter to the available actual datasets. For example, the probability of an Atlantic hurricane making landfall in a particular coastal segment from the hypothetical sample can be compared to the actual number of landfalls since 1871, the beginning year of published records by NOAA.[2] Similarly, the model's probability of a hurricane with a particular size, path or intensity can be validated by comparison to historical hurricane records. The wind speed generated at a particular location for a simulated historical event can be compared to the actual observed wind speed. Finally, the predicted damages and insured losses to a particular type of structure subjected to a given wind speed can be compared to the actual damages and losses sustained at locations where that wind speed was present in a historical event.

At each step of the process, error is introduced to the extent that model results do not fully agree with actual observations. Model error is present because no model can precisely replicate an actual physical event. By definition, a model is a representation of the event; it seeks to capture the key underlying variables and their inter-relationships, leaving estimation errors from variables and inter-relationships not captured. Simulating a large number of hypothetical events can reduce certain of these errors. Some of the key contributors to hurricane model error are:

- In determining the likelihood of events of various sizes, intensities and paths
    - — limited availability of key parameters for a sufficient number of historical events
    - — limited availability of information on the historical frequency of rare events
    - — limited ability to predict changes in hurricane landfall frequency over time.

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[2] The National Oceanic and Atmospheric Administration of the U.S. Department of Commerce, publishes track and parameter information on hurricanes since 1871. In addition, there are numerous summaries and studies of prior documented storms. In recent years, there has also been research based on proxy approaches that derive past hurricane activity from geologic and biologic evidence.

- In estimating the wind speeds at specific locations affected by each event
    - limited availability of wind speed data for a sufficient number of locations for a sufficient number of historical events
    - limited ability to simulate the actual impact of land, vegetation and man-made objects on wind speeds
    - limited ability to simulate the possible variations in windfield shape (i.e., the distribution of wind velocity by distance and direction from the center), particularly including localized bursts of wind.

- In determining the damage to property
    - limited knowledge of precise types and values of property exposed at the time of the event
    - limited knowledge of the construction quality of those properties.

- In determining the insured losses
    - limited knowledge of claims adjusting practices of companies
    - limited availability of accurate historical insurance claims data in sufficient detail by location and coverage
    - limited knowledge of potential impact of governmental actions and demand surge
    - limitations in our ability to determine the portion of damage due to flood rather than wind.

These errors can be significant or modest in relation to the final results produced by the model. For example, Kelly and Zeng (Kelly and Zeng 1996) suggest that, based on their experience with one hurricane model, the errors introduced by the damage step are generally much less than a single order of magnitude while the errors introduced by the event steps can be several orders of magnitude. In other words, the model's estimate of expected losses for a particular risk might be off by 20% due to a mis-specified damage function, but those same expected losses might be off by 200% due to mis-estimation of the landfall probability.

Macro Validation Dataset

In the authors' view, public (and regulatory) acceptance of these models is hampered by the complexity of this layered validation approach, which leaves the outside user with an unclear picture of the overall goodness of fit between the model and historical data. The problem is only exacerbated when the model formulas and the validation results are treated as proprietary by the modelers. Accordingly, we set out to develop and publish a dataset permitting macro validation – one that would allow a lay person to compare the overall results of the model to an historical record. In addition to a comparison of model results to historical results, the dataset also demonstrates the limitations of the historical experience and data.

The macro validation dataset consists of the aggregate insured losses from each hurricane affecting the continental United States from 1900 through 1999. The dataset includes storms determined by NOAA to have caused hurricane conditions over land. Exhibit 1 lists these hurricanes[3] and shows their magnitude, as determined by NOAA, in each of the coastal states affected. The overall losses for each event have been allocated to county, based on estimates of relative loss within the state. The historical losses in each county have then been "trended" – adjusted from the conditions at the time to those existing today. Our work extends and improves upon similar work published by Pielke and Landsea (Pielke and Landsea 1998), which looks at total economic damages rather than insured losses and does not cover the entire 20th century.

Because the models are used primarily by the insurance industry, our focus was to estimate the aggregate insured losses directly sustained by the U.S. insurance industry. The same approaches described in the paper can be used to project total economic losses as well.

The remainder of this paper has two major sections. Section II describes the construction of the validation dataset, which consists of the losses from each historical event adjusted to 2000 cost and exposure levels. Section III illustrates the use of the dataset.

II. CONSTRUCTING THE VALIDATION DATA

Historical Losses

Data on the losses sustained from past hurricanes is available from a variety of public and private sources. The various data sources differ as to the types of costs included, the level of detail, and whether the figures are actual results or estimates.

The National Weather Service (NWS, which is part of NOAA) compiles data on the economic impact of each U.S. hurricane; that data is published annually in the *Monthly Weather Review*. A summary of this historical data from 1900 forward is presented in *Deadliest, Costliest, and Most Intense United States Hurricanes of This Century* (Hebert, Jarrell and Mayfield 1996). The data published by NWS are estimates based on surveys of the areas affected and consultations with experts, not a tabulation of actual costs incurred. The estimates include all direct costs stemming from the event, including insured losses, uninsured property losses, federal disaster assistance outlays, agriculture and environmental losses, etc. (Technically, the insured losses include some secondary costs due to the inclusion of business interruption and additional living expense claims.) Typically, the estimates for each event are not broken down by state or county. Separate estimates are made when a single hurricane makes more than one distinct landfall.

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[3] The summary tables on Exhibit 1, Sheet 3, show total storms by category and state. Appendix A displays key statistics on hurricanes affecting Bermuda, Hawaii, Puerto Rico and USVI during the 20th century.

Property Claim Services, Inc. (PCS), a subsidiary of Insurance Services Office (ISO), prepares estimates of the direct insured losses for each natural catastrophe, including hurricanes. Their historical data extends back only to 1949. To be considered a catastrophe by PCS, the aggregate insured losses from the event must exceed a set dollar threshold. This threshold was originally set at $1 million; over time it has been raised to its current level of $25 million. The estimates published by PCS are based on surveys of insurers' reported loss activity, insurer market share data and a database of the number and types of structures by county. The current PCS practice is to prepare an initial loss estimate approximately two weeks after the event and to revise its estimates based on new information after subsequent 60 day periods until the estimate stabilizes, at which point no further revisions are made. Until the late 1980s, PCS estimates were rarely updated after 60 days and evidence suggests that these estimates often underestimated the total loss.

The PCS estimates are intended to include all insured losses paid directly by U.S. insurers under property and inland marine insurance coverages. This would include payment of the costs to repair or replace damaged property and contents, reimbursement for alternative housing while repairs are effected, and compensation for business interruption losses. The insurer's specific expenses for adjusting the claims are not included. The PCS estimates for each event are currently broken down by state, separately for personal property, commercial property and automobile, and also include the number of claims and the average payment.

Because they are prepared by different organizations using different source information, the NWS and PCS estimates of losses are not always consistent. Special studies have also been made in the past to collect actual insured losses for the industry. In a 1986 study, the All-Industry Research and Advisory Council (AIRAC) conducted a survey of insurers, asking them to provide their direct losses for the seven hurricanes occurring in 1983 and 1985 (AIRAC 1986). Responses were obtained from 95 insurers, who represented between 63% and 80% of the market share in the states affected. AIRAC then extrapolated the survey results to an industry-wide level based on the collective market shares of the respondents in the states affected by each event. (Collective market shares were based on premiums written by state.) In the AIRAC survey, insurers were requested to report their direct incurred losses including windstorm pool assessments, but excluding claim adjustment expenses. The AIRAC study indicated higher losses than the PCS estimates for 4 of the 7 hurricanes studied, including the 3 largest. In total for the seven storms, the AIRAC survey indicated losses of approximately $2.7 billion, 50% higher than the PCS estimate of $1.8 billion, as shown in Table 1.

TABLE 1

Comparison of PCS Estimates of Industry Losses to Estimates from the AIRAC Survey

Year	Hurricane	PCS Estimate	AIRAC Survey	Percent Difference
1983	Alicia	$675,000	$1,274,500	-47%
1985	Bob	13,000	9,946	31%
1985	Danny	37,000	24,509	51%
1985	Elena	543,000	622,050	-13%
1985	Gloria	418,000	618,299	-32%
1985	Juan	44,000	78,448	-44%
1985	Kate	77,000	67,830	14%
TOTAL		$1,807,000	$2,695,582	-49%

Certain state insurance departments also conduct studies of hurricane losses in their state. In the case of hurricane Andrew, the Florida Department of Insurance compiled the actual losses for the insurance industry. Under emergency rules promulgated by the Department, each insurer operating in the state was required to report their accumulated losses to the Department at the end of each quarter. The reported figures include only losses (i.e., not including costs of adjusting the claims), for Florida business only. Losses in Louisiana and elsewhere are not included.[4] The results as of March 31, 1994 were published in *The Journal of Reinsurance* (Lilly, Nicholson and Eastman 1994). In the aggregate, insurers reported 798,356 claims from hurricane Andrew, with a total dollar cost of approximately $16.1 billion. As of that date, insurers had paid out roughly 91.9% of that figure, with the balance representing their estimate of payments still to be made pending final adjustment. The final PCS estimate for Florida losses from Hurricane Andrew was $15 billion.

In constructing our validation dataset, we selected what we considered to be the best available estimate of the industry aggregate insured losses for each event. For events where no PCS or other direct estimate of insured losses was available, we estimated the insured losses as a percentage of the NWS/NOAA total loss estimate. There were 49 hurricanes for which no estimate of actual loss was available. This occurred only for weaker hurricanes that caused relatively small actual losses, generally those with under $1 million of actual losses prior to 1950. For these events, actual loss was estimated judgmentally. These judgmental estimates were selected to be consistent with estimates of total loss by year in Hebert, Jarrell and Mayfield

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[4] Anecdotally, we would point out that insurance losses could be sustained by policyholders far away from the event. For example, in the case of hurricane Andrew an insurer sustained a loss by a Massachusetts policyholder who lost a camera while vacationing in Florida at the time. This loss would not be included in the figures quoted above.

(Hebert, Jarrell and Mayfield 1996). The normalized loss for these hurricanes represents only about 3% of the total normalized loss.

Allocation of Losses to County

Once a best estimate of the industry aggregate insured losses was selected, the losses were allocated to county. We devised a damage index for each county that reflected the estimated relative impact of the hurricane. The damage indices for all counties affected by an event were scaled such that, when multiplied by the number of housing units in the county at the time, the sum across all counties balanced to the selected industry aggregate insured loss.

The damage indices for an event are derived from the ToPCat hurricane model. The use of these indices means that the allocation of losses to county (and to state, prior to PCS estimates) is model-dependent. Nevertheless, the total insured loss estimates for each storm are not model dependent as they are balanced to the selected industry loss estimate.

Trending

The historical losses reflect the price levels and property exposure existing at the time of the event. If the same event were to happen today, the losses arising from that event would reflect

- today’s price levels, reflecting the general inflation in price levels that occurred during the intervening period
- the current stock of properties and contents, reflecting the increase in the number of structures of various types, any increases in the average size or quality of the structures, and the greater amounts and value of the typical contents in the structures
- the current insurance system, including increases in the prevalence of insurance, the expansion of coverages, and changes in claim practices or the legal system governing how claims are settled.

Actuaries are accustomed to adjusting historical costs to current conditions by means of trend factors that account for changes in conditions during the intervening period. We developed trend factors to account for each of the three components above. Our goal was to adjust all historical losses forward to conditions prevailing in 2000.

The impact of monetary inflation was measured by reference to the Implicit Price Deflator (IPD) for Gross National Product, published by the Department of Commerce in their annual Economic Report to the President. An inflation trend factor was computed by dividing the estimated value of the IPD at year-end 2000 by the value at the time of the event. The IPD is only available back to 1950. For prior years, a 3.5% annual trend was assumed.

Of course, property values have increased by more than inflation. For example, the average size of houses and the amount of contents have gradually increased over time. The national growth in the value of property was measured using estimates of Fixed Reproducible Tangible Wealth (FRTW) published by the Department of Commerce's Bureau of Economic Analysis. FRTW measures the total value of all structures and equipment owned by businesses, institutions, and government as well as residential structures and durable goods owned by consumers. In this context, structures include buildings of all types, utilities, railroads, streets and highways, and military facilities. Similarly, equipment includes industrial machinery and office equipment, trucks, autos, ships, and boats. While FRTW includes some elements not entirely relevant to property insurance such as military facilities and highways, these elements represented less than 10% of the total as of year-end 1995.

FRTW estimates are prepared annually; time-series data is presented on several different bases. We utilized the Real Net Stock of FRTW series, which is net of depreciation, and adjusted to 1992 dollar levels such that it accounts only for real and not inflationary growth in the net value of property over time. A national property growth factor was computed by dividing the estimated value of the Real Net Stock of FRTW at year-end 2000 by the corresponding value at the time of the event. This growth factor accounts for aggregate growth in property values due to population growth and increases in per capita wealth. The selected FRTW series is only available back to 1925. For prior years, we assumed a 2.5% per year trend.

The national growth in property exposure has been far from uniform geographically. The general migration of the U.S. population towards the South and West over the last several decades has been well publicized. Of particular relevance to potential hurricane losses is the increased concentration of people and property in vulnerable coastal locations.

Pielke and Landsea (Pielke and Landsea 1998) have suggested that the national property growth factor be adjusted based on relative growth of the population in the affected region versus the nation as a whole. They introduce a population adjustment equal to the ratio of the growth in population in the affected coastal counties to the growth in population nationally. While this approach reasonably captures the migration of the U.S. population to the Sunbelt, it fails to take into account the explosive growth in vacation homes. (Census population data accounts for people at the location of their principal residence.) This issue is particularly significant because a large number of vacation homes are located in coastal resort areas: Cape Cod, Long Island, Cape Hatterras, Florida, etc.

We improve upon Pielke and Landsea's approach by using the growth in the total number of housing units in each county during the time period for which it is available, rather than the growth in population. Housing unit data is available from the Census, back to 1940. (County data from the decennial census was interpolated to obtain annual housing unit estimates for each county. Prior to 1940, we used population statistics to estimate housing units.)

A second improvement relates to the way in which the county data is used. Pielke and Landsea (Pielke and Landsea 1998) identified the coastal counties that were affected by each event and based their geographic adjustment on the aggregate change in population for all counties combined. Because we estimated the insured loss by county, we were able to weight the growth by relative damage in each county.

Since we are adjusting insured losses, a final adjustment was necessary to account for changes in the insurance system. Ideally, this adjustment should account for each of the following.

- *Changes in the prevalence of insurance coverage.* Coverage for the wind peril is fairly universal today, primarily because mortgage lenders require it. (This requirement does not exist for earthquake insurance, resulting in significantly lower market penetration for that coverage, even in earthquake-prone areas.) Property that is uninsured tends to be lower valued. Prior to the introduction of multiple peril policies in the 1960s, wind coverage was far less universal. The introduction of FAIR plans and wind pools has also contributed to more universal coverage.

- *Changes in the level and structure of coverage.* Competition has led to gradual increases in the level of coverage offered by standard insurance policies. For example, coverage for contents, generally written as a standard percentage of building coverage on personal lines policies, has increased over time. More significantly, there has also been a longer-term trend away from actual cash value to replacement cost coverage. This shift has been widespread in homeowners; even some business-owners is now written on a replacement cost basis. Conning (Conning & Company 1996) has pointed out that this change in coverage significantly increases the insurer's exposure, essentially changing it from a net (of depreciation) to a gross value basis. One coverage trend has acted to reduce insurers hurricane exposure in recent years. Subsequent to Hurricane Andrew, there was a significant increase in required deductibles in coastal areas. While individuals have tended to resist voluntary increases in retentions, there has been a longer-term trend toward larger self-insured retentions in the commercial insurance sector.

- *Changes in the typical practices regarding claim settlements.* While this element may be the hardest to specify, industry professionals believe that policyholders have a greater propensity to file claims, particularly claims relating to minor or consequential damage. At the same time, insurers are more willing to interpret the coverage in a manner favorable to the insured (contrary to public perception), in the interests of customer satisfaction, particularly after a catastrophe.

Taken collectively, all of these factors work to increase the extent of economic losses covered by insurance, particularly as one goes further back in time. The insurance utilization index was derived from a review of ratios of PCS insured loss estimates to NOAA economic loss estimates from 1949 through 1995. The data and selected insurance utilization index are compared in the graph on Appendix B, Exhibit 2. The selected index from 1950 through 1995 was based on a linear least squares fit of the data. The fit produced a line from approximately 21% in 1950 through 55% in 1995. From 1995 through 2000, the insurance utilization rate was kept at a constant 55% to judgmentally reflect the increasing use of deductibles. Prior to 1950, a linear trend from 10% in 1900 through 21% in 1950 was judgmentally selected. As total economic losses were used as the starting point for normalization prior to 1949, this latter assumption has virtually no impact on normalized losses.

Appendix B, Exhibit 1 displays the historical growth rates in the IPD and FRTW indexes as well as the national growth in population and housing units.

Mathematically, the trend procedure can be expressed as follows:

$$L_{c,2000} = L_{c,y} \text{ x } \left(\frac{IPD_{2000}}{IPD_y} \right) \text{x} \left(\frac{FRTW_{2000}}{FRTW_y} \right) \text{x} \left(\frac{HU_{c,2000} / HU_{c,y}}{HU_{2000} / HU_y} \right) \text{x} \left(\frac{INS_{2000}}{INS_y} \right)$$

Where:

$L_{c,y}$	is the insured loss in county c from an event in year y
IPD_y	is the value of the Implicit Price Deflator for year y
$FRTW_y$	is the Real Net Stock of Fixed Reproducible Tangible Wealth for year y
$HU_{c,y}$	is the estimated number of Census Housing Units in county c in year y
INS_y	in the insurance utilization index for year y

Limitations of the dataset

We believe that the validation dataset produced by the normalization process described above is useful for comparing the results of U.S. hurricane models to the historical record. The dataset provides a macro tool that can be used by model users with limited knowledge of the detailed assumptions underlying the model. Nevertheless, it should be expected that probabilistic model results will vary from the results of the normalization process. The causes of this variation can be segregated into two types: variations caused by limitations in the normalization model, and variations caused by basic differences between a historical normalization process and a probabilistic model. A summary of the causes of each type is outlined below.

- Limitations of the normalization process itself (these limitations would also relate to comparisons of normalized and modeled historical storm results)
    - — unavailability of insured loss estimates prior to the inception of PCS estimates in 1949
    - — inaccuracies in the historical PCS insured loss estimates (as previously noted, the AIRAC study in 1986 and the Florida Department of Insurance study of Hurricane Andrew in 1992 both indicated significantly different levels of industry losses than the PCS estimates)

- leveraging in the trending procedure (small changes in the initial estimate of the insured loss or its allocation to county can produce large changes in the normalized amount for events that occurred many years ago; this distortion should be less significant at the statewide level or for groups of neighboring counties)
- trending of exposures based solely on housing units (normalized losses in counties with commercial property growth significantly different than housing unit growth will be distorted)

- Basic differences between historical normalization and probabilistic models

  - probabilistic models provide a representative sampling of possible hurricane paths, sizes and intensities, which can produce results that differ significantly from the results of one hundred-year period that are influenced greatly by the location of the 5 or 10 largest or most intense storms
  - probabilistic model industry loss estimates are dependent on the accuracy of the modeler’s estimate of total insured property exposures by ZIP code or county that are used in the modeling to estimate industry loss (these industry exposure sets are independently developed by modelers, or may be developed by users, based on insurance industry or external statistics on property values)
  - probabilistic models may include tropical storms that do not reach hurricane strength or strafing hurricanes that do not produce hurricane winds over land (these differences can distort loss comparisons as well as frequency comparisons)

Results

Exhibit 2 presents an illustrative calculation of losses in Mississippi from Hurricane Camille. The inputs are the year of the event, the estimated total losses for the event, by state (from PCS) and the damage index for each county. To illustrate how inflation, real growth in property values, population migration, insurance utilization and housing units combine to increase the level of economic losses from a hurricane, we will look at the figures for the two counties contributing most to the Mississippi losses: Hancock and Harrison. Since 1969, housing units have grown by 222.8% in Hancock and 90.7% in Harrison. The normalization process brings the Hancock losses up by 2716%, from approximately $20 million to $549 million, while the Harrison losses increase by 1604%. The Hancock increase is attributed to:

Inflation	297.4%
Growth in wealth per capita (2.317 ÷ 1.703)	36.1%
Growth in insurance utilization	55.6%
Growth in housing units	222.8%

Thus, in Hancock County, the impact of inflation (297.4%) is less than the combined impact of the other three factors (584% = (1.361 x 1.556 x 3.228)-1), the most important of which is the growth in the number of housing units.

Exhibit 3 summarizes the estimated actual and normalized losses for hurricanes affecting the U.S. during the 20th century. The normalized losses for these 164 hurricanes average $1.75 billion per storm, or $2.87 billion per year. The resulting size of loss distribution by Saffir-Simpson category on Exhibit 3, Sheet 4 shows the impact of storm severity on insurance losses. While only about 9% of historical events were category 4 hurricanes, those events produced 55% of the normalized losses. Interestingly, the category 5 hurricanes have not produced a similarly skewed impact because the only two such events (#2 in 1935 and Camille in 1969) did not hit densely populated areas.

Exhibit 3, Sheet 4 also shows the variation in normalized loss by decade, most notably the high losses in the twenties and the relatively low losses in the seventies and eighties.

III USING THE VALIDATION DATA

Severity Distributions by State

Exhibit 4 displays annual aggregate (Sheet 1) and maximum single occurrence (Sheet 2) distributions by state based on the normalized losses from 1900 to 1999. Due to the low probability of having more than one hurricane per year in most states, the results in Sheets 1 and 2 are quite similar. Florida, with almost 50% of the expected annual losses, and Texas, with over 21%, dominate the results. The total annual aggregate distributions at the longer return periods (20 years and greater) are also driven by the worst storms in those two states.

As 100 years is not a sufficiently long time period to credibly determine the likely loss levels at the longer return periods, random elements are evident in the state distributions. For example, the 100-year loss for South Carolina, Hurricane Hugo in 1989, is approximately 10 times the 100-year loss in Georgia, Hurricane Opal in1995. Georgia was not hit heavily in the 20th century, having had no landfalling events, but saw several major hurricanes in the 19th century. On a probabilistic basis, it is reasonable to expect the 100-year loss in Georgia to be somewhat closer to the South Carolina 100-year loss.

The normalized results by state are compared to those of a hypothetical representative probabilistic hurricane model (“Model T”) in Exhibit 6, Sheets 1 and 2. Sheet 1 compares normalized and modeled frequency and severity distributions by Saffir-Simpson category and by return period for Texas, Florida and countrywide. Sheet 2 compares normalized and modeled expected losses by state. Based on the Model T indications, Georgia, New Jersey and New York were relatively lucky during the 20th century, while Texas was the most unlucky. Comparisons such as those in Exhibit 6 could be used to learn more about the assumptions behind a probabilistic model. For example, in this case it would be useful to learn the answers to questions such as:

- What data are the Model T frequency distributions based on, and why do they differ from the 20th century distributions?
- What are the paths and Saffir-Simpson categories of the typical 50 year and 100 year return events in Model T, compared to the worst events by state during the 20th century?
- Why are the Model T expected losses in Texas so much lower and New York and New Jersey so much higher than the normalized 20th century expected losses?
- How do these and other key differences from the 20th century storm set affect the results of Model T on a specific insurer's portfolio?

Severity Distributions by County

Exhibit 5 displays annual aggregate loss distributions for counties with significant annual expected losses in Texas and Florida. Random elements are even more evident at the county level. For example, Dade County has expected losses over 3 times expected losses in Broward County and over 5 times those in Palm Beach County, Florida, due to the influence of Hurricane Andrew and storm number 6 of 1926.

These results could be compared to the results of a probabilistic model to determine how the model's expected losses vary from historical results in these counties. For example, Model T indicates expected losses in Dade County 27% higher than in Broward County and 36% higher than in Palm Beach County. Of course, as one looks at smaller geographic areas (e.g., county rather than state), one would expect larger differences between a model and the historical results of one hundred-year period.

Estimates of Losses from Historical Events

Exhibit 6, Sheet 3 compares the normalized losses from the 50 largest events of the 20th century to the Model T results for those same events. Here we see evidence that modeled individual storm estimates often differ significantly from the normalized amounts. Differences of over 50% occur on 18 of the 50 storms. These differences occur primarily on storms prior to the advent of PCS estimates in 1949. Only 2 of the 18 (Hurricane King in 1950 and Hurricane Donna in 1960) have normalized estimates based on PCS. These differences indicate the uncertainty in both normalizing and modeling these older storms.

In conclusion, the normalized hurricane loss database provides a variety of tools for hurricane model users to perform macro validation tests of model assumptions. In keeping with the spirit of this call for papers on data, the authors will provide interested readers with an electronic copy of the normalized loss database by event and county. We trust that future research will expand the scope of hurricane loss data to include not only hurricanes of the 21st century, but improvements to this 20th century database, and perhaps also the addition of estimates of hurricane losses in prior centuries.

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Exhibit 1
Sheet 1

Hurricanes Affecting the Continental U.S. 1900 - 1999

Year	Hurricane Number/ Name	Date of First US Landfall	Category and Coastal States Affected																									
			TX So	TX Ce	TX No	TX	LA	MS	AL	FL NW	FL SW	FL SE	FL NE	FL	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	CW
1900	1	08-Sep			*4*	*4*																						4
1901	3	10-Jul															*1*											1
1901	4	14-Aug					*2*	2																				2
1903	3	11-Sep								1		*2*		*2*														2
1903	4	16-Sep																			*1*	1	1					1
1904	2	14-Sep														*1*	L											1
1906	2	16-Jun										*1*		*1*														1
1906	4	17-Sep														*3*	3											3
1906	5	27-Sep						*3*	3	L																		3
1906	8	17-Oct									L	*2*		*2*														2
1908	2	30-Jul															*1*											1
1909	3	21-Jul			*3*	*3*																						3
1909	5	27-Aug	*2*			*2*																						2
1909	7	20-Sep					*4*																					4
1909	9	11-Oct									L	*3*		*3*														3
1910	2	14-Sep	*2*			*2*																						2
1910	4	17-Oct									*3*	L		*3*														3
1911	1	11-Aug							*1*	1				1														1
1911	2	27-Aug													2	*2*												2
1912	3	13-Sep							*1*																			1
1912	5	16-Oct	*1*			*1*																						1
1913	1	27-Jun	*1*			*1*																						1
1913	2	02-Sep															*1*											1
1915	2	17-Aug			*4*	*4*																						4
1915	4	04-Sep								*1*				*1*														1
1915	5	29-Sep					*4*																					4
1916	1	05-Jul					L	*3*	3																			3
1916	2	21-Jul																							*1*			1
1916	3	14-Jul														*1*												1
1916	4	18-Aug	*3*			*3*																						3
1916	13	18-Oct							2	*2*				*2*														2
1916	14	15-Nov									*1*			*1*														1
1917	3	28-Sep								*3*				*3*														3
1918	1	06-Aug			L		*3*																					3
1919	2	14-Sep	*4*			*4*					4			4														4
1920	2	21-Sep					*2*																					2
1920	3	22-Sep															*1*											1
1921	1	22-Jun		*2*		*2*																						2
1921	6	25-Oct								L	*3*		2	*3*														3
1923	3	15-Oct					*1*																					1
1924	4	15-Sep								*1*				*1*														1
1924	7	20-Oct									*1*	L		*1*														1
1925	2	01-Dec									*1*		L	*1*														1
1926	1	27-Jul											*2*	*2*														2
1926	3	25-Aug					*3*																					3
1926	6	18-Sep						L	3	3	3	*4*		*4*														4
1928	1	07-Aug										*2*	L	*2*														2
1928	4	16-Sep										*4*	2	*4*	1	1												4
1929	1	28-Jun		*1*		*1*																						1
1929	2	28-Sep								2		*3*		*3*														3
1932	2	13-Aug			*4*	*4*																						4
1932	3	01-Sep							*1*																			1
1933	5	30-Jul	2			2						*1*		*1*														2
1933	8	23-Aug															*2*	2										2
1933	11	04-Sep	*3*			*3*																						3
1933	12	03-Sep										*3*		*3*														3
1933	13	16-Sep															*3*											3
1934	2	16-Jun					*3*																					3
1934	3	25-Jul	*2*			*2*																						2
1935	2	03-Sep								2	*5*			*5*														5
1935	6	04-Nov									L	*2*		*2*														2
1936	3	27-Jun	*1*	L		*1*																						1
1936	5	31-Jul								*3*				*3*														3
1936	13	18-Sep															*2*											2
1938	2	14-Aug					*1*																					1
1938	4	21-Sep																				*3*	3	3	3			3
1939	2	11-Aug								1		*1*		*1*														1
1940	2	07-Aug			*2*	*2*	2																					2
1940	3	11-Aug													2	*2*												2
1941	2	23-Sep			*3*	*3*																						3

Exhibit 1
Sheet 2

Hurricanes Affecting the Continental U.S. 1900 - 1999

Year	Hurricane Number/ Name	Date of First US Landfall	Category and Coastal States Affected																									
			TX So	TX Ce	TX No	TX	LA	MS	AL	FL NW	FL SW	FL SE	FL NE	FL	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	CW
1941	5	06-Oct								2	2	*2*		*2*														2
1942	1	21-Aug			*1*	*1*																						1
1942	2	29-Aug		*3*	L	*3*																						3
1943	1	26-Jul			*2*	*2*																						2
1944	3	01-Aug															*1*											1
1944	7	14-Sep															3	3				3	3	*3*	2			3
1944	11	18-Oct									*3*		2	*3*														3
1945	1	24-Jun								*1*				*1*														1
1945	5	26-Aug		*2*	L	*2*																						2
1945	9	15-Sep										*3*		*3*														3
1946	5	07-Oct									*1*			*1*														1
1947	3	24-Aug			*1*	*1*																						1
1947	4	17-Sep					3	3			2	*4*		*4*														4
1947	8	11-Oct									*1*	1		*1*	2	2												2
1948	5	03-Sep					*1*																					1
1948	7	21-Sep									*3*	2		*3*														3
1948	8	05-Oct									L	*2*		*2*														2
1949	1	24-Aug															*1*											1
1949	2	26-Aug										*3*	L	*3*	L													3
1949	10	03-Oct			*2*	*2*																						2
1950	Baker	30-Aug							*1*																			1
1950	Easy	04-Sep								*3*				*3*														3
1950	King	17-Oct										*3*	L	*3*														3
1952	Able	30-Aug														*1*												1
1953	Barbara	13-Aug															*1*											1
1953	Carol	07-Sep																									*1*	1
1953	Florence	26-Sep								*1*				*1*														1
1954	Carol	31-Aug															2					*3*	3	3	L	L	L	3
1954	Edna	11-Sep																					L	L	*3*	L	1	3
1954	Hazel	15-Oct														4	*4*	L	2	L	L	L						4
1955	Connie	12-Aug															*3*	1	L									3
1955	Diane	17-Aug															*1*											1
1955	Ione	19-Sep															*3*											3
1956	Flossy	24-Sep					*2*			1				1														2
1957	Audrey	27-Jun			*4*	*4*	4																					4
1959	Cindy	08-Jul														*1*												1
1959	Debra	24-Jul			*1*	*1*																						1
1959	Gracie	29-Sep														*3*												3
1960	Donna	09-Sep									*4*		2	*4*			3					3	2	2	1	1	1	4
1960	Ethel	15-Sep						*1*																				1
1961	Carla	11-Sep		*4*	L	*4*																						4
1963	Cindy	17-Sep			*1*	*1*																						1
1964	Cleo	26-Aug										*2*	L	*2*														2
1964	Dora	09-Sep											*2*	*2*	L													2
1964	Hilda	03-Oct					*3*																					3
1964	Isbell	14-Oct									*2*	2		*2*														2
1965	Betsy	08-Sep					3	L				*3*		*3*														3
1966	Alma	09-Jun								*2*				*2*														2
1966	Inez	04-Oct									*1*	L		*1*														1
1967	Beulah	20-Sep	*3*			*3*																						3
1968	Gladys	18-Oct								*2*			1	*2*														2
1969	Camille	17-Aug					5	*5*																				5
1969	Gerda	09-Sep																									*1*	1
1970	Celia	03-Aug	*3*	L		*3*																						3
1971	Edith	16-Sep					*2*																					2
1971	Fern	09-Sep		*1*		*1*																						1
1971	Ginger	30-Sep															*1*											1
1972	Agnes	19-Jun								*1*				*1*				L	L			1	1					1
1974	Carmen	07-Sep					*3*																					3
1975	Eloise	23-Sep							L	*3*				*3*														3
1976	Belle	09-Aug																				*1*						1
1977	Babe	04-Sep					*1*																					1
1979	Bob	11-Jul					*1*																					1
1979	David	03-Sep										2	*2*	*2*	2	2	L											2
1979	Frederic	12-Sep						3	*3*	L																		3
1980	Allen	09-Aug	*3*			*3*																						3
1983	Alicia	17-Aug			*3*	*3*																						3
1984	Diana	11-Sep															*3*											3
1985	Bob	24-Jul														*1*												1
1985	Danny	15-Aug					*1*																					1

Exhibit 1
Sheet 3

Hurricanes Affecting the Continental U.S. 1900 - 1999

Year	Hurricane Number/ Name	Date of First US Landfall	Category and Coastal States Affected																									
			TX So	TX Ce	TX No	TX	LA	MS	AL	FL NW	FL SW	FL SE	FL NE	FL	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	CW
1985	Elena	01-Sep						*3*	3	3				3														3
1985	Gloria	27-Sep															3				L	*3*	2	L	L	2	1	3
1985	Juan	28-Oct					*1*																					1
1985	Kate	21-Nov								*2*				*2*	L													2
1986	Bonnie	26-Jun			*1*	*1*																						1
1986	Charley	17-Aug															*1*	1										1
1987	Floyd	12-Oct									*1*			*1*														1
1988	Florence	09-Sep					*1*																					1
1989	Chantal	01-Aug			*1*	*1*																						1
1989	Hugo	21-Sep														*4*	L											4
1989	Jerry	15-Oct			*1*	*1*																						1
1991	Bob	19-Aug																				2	2	*2*	2		L	2
1992	Andrew	24-Aug					3				3	*4*		*4*														4
1993	Emily	01-Sep															*3*											3
1995	Erin	01-Aug							L	L		*1*	L	*1*														1
1995	Opal	04-Oct							L	*3*				*3*	L													3
1996	Bertha	12-Jul															*2*	L										2
1996	Fran	05-Sep														L	*3*	L	L									3
1997	Danny	18-Jul					*1*		L																			1
1998	Bonnie	26-Aug														L	*2*	1										2
1998	Earl	02-Sep								*1*				*1*														1
1998	Georges	28-Sep					L	*2*	L		2			2														2
1999	Bret	22-Aug	*3*			*3*																						3
1999	Floyd	16-Sep											L			L	*2*	L	L	L	L	L	L					2

Number of Hurricanes Affecting, by Category:

	TX So	TX Ce	TX No	TX	LA	MS	AL	FL NW	FL SW	FL SE	FL NE	FL	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	CW
1	3	2	7	12	9	1	4	10	7	5	1	19	1	6	10	3			1	3	2		2	1	5	61
2	4	2	3	9	5	2	1	7	4	10	7	16	4	4	6	1	1			1	3	2	2	1		38
3	6	1	3	10	8	5	5	7	6	7		17		2	10	1				5	3	3	2			48
4	1	1	4	6	3				2	4		6		2	1											15
5					1	1			1			1														2
Total	14	6	17	37	26	9	10	24	20	26	8	59	5	14	27	5	1	0	1	9	8	5	6	2	5	164

Additional areas with normalized damage greater than $25 million:

	TX So	TX Ce	TX No	TX	LA	MS	AL	FL NW	FL SW	FL SE	FL NE	FL	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	CW
L	0	2	4	1	2	2	5	4	4	3	7	3	4	3	3	5	4	2	3	2	2	2	2	2	2	0

Number of Hurricanes making First Landfall, by Category:

	TX So	TX Ce	TX No	TX	LA	MS	AL	FL NW	FL SW	FL SE	FL NE	FL	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	CW
1	3	2	7	12	9	1	4	6	7	4		17		5	10				1	1			1		2	63
2	3	2	3	8	4	1		4	1	7	3	15		2	5							1				36
3	6	1	3	10	5	3	1	5	4	7		16		2	6					3		1	1			48
4	1	1	4	6	2				1	4		5		1	1											15
5						1			1			1														2
Total	13	6	17	36	20	6	5	15	14	22	3	54	0	10	22	0	0	0	1	4	0	2	2	0	2	164

Notes:

Coastal states affected, and category designations according to Saffir-Simpson Hurricane Scale, based on Neumann (Neumann, Jarvinen, McAdie and Elms, 1993) through 1992, and on NOAA summary reports for 1993-1999. States "affected" reflects NOAA's judgment as to which areas received hurricane conditions at the intensity of the defined Saffir-Simpson category. In some cases, the conditions may have existed only in very localized areas and may not have existed in areas that contained significant amounts of insured property. Additional states with normalized losses greater than $25 million noted by 'L'. First landfall indicated by italics (strafing of coastal islands not considered as first landfall if subsequent landfall more significant).

Saffir-Simpson Scale Number (Category)	Central Pressure (Millibars)	OR Winds (MPH)	OR Surge (Feet)
1	>979	74-95	4-5
2	965 - 979	96-110	6-8
3	945 - 964	111-130	9-12
4	920 - 944	131-155	13-18
5	<920	>155	>18

Coastal County Definitions:

Texas South is Cameron to Nueces Counties
Texas Central is San Patricia to Matagorda Counties
Texas North is Brazoria to Orange Counties

Florida Northwest is Escambia to Pasco Counties
Florida Southwest is Pinellas to Monroe Counties
Florida Southeast is Dade to Indian River Counties
Florida Northeast is Brevard to Nassau Counties

Exhibit 2

Normalization of Catastrophe Losses for Inflation and Real Growth in Property

Hurricane Camille - August 17, 1969

State	County	Housing Units At Time Of Event 1969	Damage Index	Estimated Losses (000's) At Time Of Event 1969	Growth in Number of Housing Units	Overall Adjustment Factor	Estimated Losses (000's) Adjusted to 2000
MS	Amite County	4,353	0.6%	$ 26	38.4%	1164%	$ 306
MS	Attala County	6,586	1.0%	69	19.2%	1003%	690
MS	Carroll County	3,017	1.1%	34	53.7%	1293%	434
MS	Choctaw County	2,824	0.1%	4	33.8%	1126%	42
MS	Clarke County	5,077	0.4%	21	50.5%	1266%	268
MS	Copiah County	7,652	1.0%	77	45.9%	1227%	947
MS	Covington County	4,207	15.9%	668	74.6%	1469%	9,811
MS	Forrest County	18,642	14.0%	2,601	71.0%	1439%	37,417
MS	George County	3,860	7.2%	279	113.1%	1792%	5,002
MS	Greene County	2,691	2.8%	76	87.8%	1580%	1,205
MS	Grenada County	6,412	0.8%	53	49.4%	1257%	669
MS	Hancock County	7,230	279.3%	20,198	222.8%	2716%	548,553
MS	Harrison County	40,778	206.9%	84,387	90.7%	1604%	1,353,784
MS	Hinds County	65,870	1.7%	1,113	51.6%	1275%	14,190
MS	Holmes County	7,145	2.2%	157	12.9%	949%	1,495
MS	Humphreys County	4,314	0.1%	5	-8.3%	771%	38
MS	Jackson County	26,463	37.2%	9,856	111.6%	1780%	175,443
MS	Jasper County	4,956	1.5%	74	42.9%	1202%	889
MS	Jefferson Davis County	3,865	21.9%	845	40.1%	1178%	9,959
MS	Jones County	18,104	3.5%	635	47.5%	1241%	7,880
MS	Lamar County	4,842	28.1%	1,362	215.8%	2656%	36,172
MS	Lawrence County	3,530	7.1%	252	58.6%	1334%	3,358
MS	Leake County	5,742	1.2%	68	48.3%	1248%	842
MS	Leflore County	13,048	0.7%	95	6.5%	896%	853
MS	Lincoln County	8,591	0.7%	59	54.9%	1303%	771
MS	Madison County	8,202	3.8%	311	289.4%	3276%	10,175
MS	Marion County	7,305	28.9%	2,108	47.6%	1242%	26,168
MS	Montgomery County	4,210	0.8%	35	22.1%	1027%	355
MS	Neshoba County	6,991	0.1%	10	66.0%	1396%	143
MS	Newton County	6,493	0.6%	40	40.6%	1183%	469
MS	Panola County	7,932	0.2%	19	71.1%	1439%	276
MS	Pearl River County	8,637	101.3%	8,753	136.2%	1987%	173,896
MS	Perry County	2,819	8.2%	232	81.5%	1527%	3,543
MS	Pike County	10,625	0.7%	75	53.0%	1287%	964
MS	Rankin County	11,753	7.3%	856	265.6%	3075%	26,319
MS	Scott County	6,581	3.9%	257	59.1%	1338%	3,437
MS	Simpson County	6,378	13.8%	882	64.6%	1384%	12,206
MS	Smith County	4,427	7.3%	321	39.9%	1177%	3,781
MS	Stone County	2,450	28.2%	690	129.4%	1930%	13,324
MS	Tallahatchie County	6,241	0.5%	31	-11.4%	745%	231
MS	Walthall County	4,006	6.3%	253	45.7%	1226%	3,096
MS	Wayne County	5,033	0.9%	44	64.2%	1381%	606
MS	Webster County	3,378	0.3%	9	36.2%	1146%	102
MS	Winston County	5,836	0.1%	5	34.1%	1128%	54
MS	Yalobusha County	4,130	0.4%	18	38.0%	1161%	204
MS	Yazoo County	8,700	0.5%	39	11.2%	935%	367
	Mississippi Total			138,000	114.6%	1805%	2,490,730
	Alabama			2,000	101.8%	1698%	33,950
	Florida			1,000	173.1%	2297%	22,972
	Louisiana			25,000	91.2%	1609%	402,137
	Event Total			166,000			2,949,789

Countrywide:	Change in Price Level - GNP Deflator	297.4%
	Real Growth in National Wealth	131.7%
	Growth in Insurance Utilization	55.6%
	Growth in Number of Housing Units	70.3%

Exhibit 3
Sheet 1

Hurricane Loss Estimates
Continental U.S. 1900 - 1999

Dollars in Thousands

Year	Hurricane Number/ Name	Total Estimated Actual Loss at Time of Event				Insured Loss Normalized To 2000	Max Loss State/Region	Max Category
		Economic	Insurance Utilization	Insured	Source			
1900	1	$ 30,000	10.0%	$ 1,500	NOAA	$ 16,485,683	TX - No	4
1901	3	100	10.2%	10	NOAA	76,846	NC	1
1901	4	925	10.2%	95	NOAA	366,142	LA	2
1903	3	800	10.7%	85	NOAA	2,124,106	FL - SE	2
1903	4	200	10.7%	21	NOAA	61,970	NJ	1
1904	2	2,000	10.9%	218	NOAA	646,193	SC	1
1906	2	100	11.3%	11	NOAA	894,836	FL - SE	1
1906	4	1,500	11.3%	170	NOAA	525,681	NC	3
1906	5	1,500	11.3%	170	NOAA	662,658	AL	3
1906	8	100	11.3%	11	NOAA	687,544	FL - SE	2
1908	2	100	11.8%	12	NOAA	37,659	NC	1
1909	3	1,900	12.0%	228	NOAA	1,119,560	TX - No	3
1909	5	100	12.0%	12	NOAA	87,098	TX - So	2
1909	7	1,100	12.0%	132	NOAA	189,900	LA	4
1909	9	5,000	12.0%	599	NOAA	7,976,601	FL - SE	3
1910	2	100	12.2%	12	NOAA	75,760	TX - So	2
1910	4	1,000	12.2%	122	NOAA	2,735,157	FL - SW	3
1911	1	675	12.4%	84	NOAA	438,296	FL - NW	1
1911	2	325	12.4%	40	NOAA	58,145	SC	2
1912	3	100	12.6%	13	NOAA	27,091	AL	1
1912	5	100	12.6%	13	NOAA	65,024	TX - So	1
1913	1	100	12.9%	13	NOAA	66,228	TX - So	1
1913	2	3,000	12.9%	386	NOAA	534,237	NC	1
1915	2	50,000	13.3%	4,988	NOAA	16,146,375	TX - No	4
1915	4	100	13.3%	13	NOAA	43,577	FL - NW	1
1915	5	13,000	13.3%	1,729	NOAA	1,709,809	LA	4
1916	1	30,000	13.5%	2,028	NOAA	3,096,434	MS	3
1916	2	125	13.5%	17	NOAA	15,474	MA	1
1916	3	100	13.5%	14	NOAA	17,866	SC	1
1916	4	350	13.5%	47	NOAA	147,702	TX - So	3
1916	13	1,125	13.5%	152	NOAA	208,433	FL - NW	2
1916	14	300	13.5%	41	NOAA	65,139	FL - SW	1
1917	3	100	13.7%	14	NOAA	28,690	FL - NW	3
1918	1	5,000	14.0%	698	NOAA	775,971	LA	3
1919	2	22,000	14.2%	3,120	NOAA	10,009,409	FL - SW	4
1920	2	3,000	14.4%	432	NOAA	348,405	LA	2
1920	3	100	14.4%	14	NOAA	18,497	NC	1
1921	1	275	14.6%	40	NOAA	31,069	TX - No, Ce	2
1921	6	2,725	14.6%	398	NOAA	1,624,995	FL - SW	3
1923	3	100	15.1%	15	NOAA	9,557	LA	1
1924	4	100	15.3%	15	NOAA	12,256	FL - NW	1
1924	7	100	15.3%	15	NOAA	86,278	FL - SE	1
1925	2	250	15.5%	39	NOAA	155,351	FL - SW	1
1926	1	3,000	15.7%	472	NOAA	1,755,434	FL - NE	2
1926	3	4,000	15.7%	629	NOAA	305,313	LA	3
1926	6	105,000	15.7%	16,506	NOAA	49,728,840	FL - SE	4
1928	1	250	16.2%	40	NOAA	132,787	FL - SE	2
1928	4	25,000	16.2%	4,040	NOAA	9,816,472	FL - SE	4
1929	1	250	16.4%	41	NOAA	18,946	TX - Ce	1
1929	2	975	16.4%	160	NOAA	356,558	FL - SE	3
1932	2	7,500	17.0%	1,278	NOAA	836,911	TX - No	4
1932	3	250	17.0%	43	NOAA	32,860	AL	1

Exhibit 3
Sheet 2

Hurricane Loss Estimates
Continental U.S. 1900 - 1999

Dollars in Thousands

		Total Estimated Actual Loss at Time of Event				Insured Loss	Max	
Year	Hurricane Number/ Name	Economic	Insurance Utilization	Insured	Source	Normalized To 2000	Loss State/Region	Max Category
1933	5	$ 250	17.3%	$ 43	NOAA	$ 67,732	FL - NE	1
1933	8	17,000	17.3%	2,934	NOAA	1,356,989	VA	2
1933	11	1,000	17.3%	173	NOAA	368,245	TX - So	2
1933	12	12,000	17.3%	2,071	NOAA	1,163,819	FL -SE	3
1933	13	1,000	17.3%	173	NOAA	75,739	NC	3
1934	2	2,600	17.5%	454	NOAA	133,959	LA	3
1934	3	250	17.5%	44	NOAA	17,976	TX -So	2
1935	2	6,000	17.7%	1,062	NOAA	1,191,386	FL - SW	5
1935	6	5,500	17.7%	974	NOAA	1,371,030	FL - SE	2
1936	3	250	17.9%	45	NOAA	17,658	TX - So	1
1936	5	250	17.9%	45	NOAA	20,289	FL - NW	3
1936	13	250	17.9%	45	NOAA	18,891	VA	2
1938	2	250	18.4%	46	NOAA	9,005	LA	1
1938	4	306,000	18.4%	56,182	NOAA	9,965,606	CT	3
1939	2	250	18.6%	46	NOAA	41,746	FL - NE	1
1940	2	250	18.8%	47	NOAA	8,223	TX - No	2
1940	3	7,000	18.8%	1,316	NOAA	293,910	SC	2
1941	2	950	19.0%	181	NOAA	64,533	TX - No	3
1941	5	7,050	19.0%	1,341	NOAA	942,310	FL - SE	2
1942	1	250	19.2%	48	NOAA	13,296	TX - No	1
1942	2	26,500	19.2%	5,099	NOAA	1,028,039	TX - No, Ce	3
1943	1	17,000	19.5%	3,308	NOAA	970,828	TX - No	2
1944	3	250	19.7%	49	NOAA	8,796	NC	1
1944	7	100,000	19.7%	19,680	NOAA	2,087,738	MA	3
1944	11	63,000	19.7%	12,398	NOAA	5,855,343	FL -SW	3
1945	1	250	19.9%	50	NOAA	20,416	FL - SW	1
1945	5	20,000	19.9%	3,980	NOAA	825,054	TX - No, Ce	2
1945	9	60,000	19.9%	11,940	NOAA	3,762,550	FL -SE	3
1946	5	5,200	20.1%	1,046	NOAA	465,074	FL - SW	1
1947	3	250	20.3%	51	NOAA	10,278	TX - No	1
1947	4	110,000	20.3%	22,374	NOAA	5,432,151	FL - SE	4
1947	8	23,000	20.3%	4,678	NOAA	1,460,391	FL - SE	2
1948	5	900	20.6%	185	NOAA	17,116	LA	1
1948	7	12,000	20.6%	2,467	NOAA	668,635	FL - SE	3
1948	8	5,500	20.6%	1,131	NOAA	224,907	FL - SE	2
1949	1	250	20.8%	52	NOAA	11,446	NC	1
1949	2			8,300	PCS	2,728,296	FL - SE	3
1949	10	6,700	20.8%	1,392	NOAA	217,219	TX - No	2
1950	Baker	500	21.0%	105	NOAA	13,449	AL	1
1950	Easy	3,300	21.0%	693	NOAA	194,890	FL - SW	3
1950	King			10,386	PCS	2,853,627	FL - SE	3
1952	Able	2,800	22.5%	630	NOAA	55,046	SC	1
1953	Barbara	1,000	23.3%	233	NOAA	19,612	NC	1
1953	Carol	500	23.3%	116	NOAA	63,152	ME	1
1953	Florence	500	23.3%	116	NOAA	10,799	FL - NW	1
1954	Carol			136,000	PCS	6,265,912	MA	3
1954	Edna			11,500	PCS	643,598	MA	3
1954	Hazel			122,000	PCS	8,196,810	NC	4
1955	Connie			25,200	PCS	1,378,549	MD	3
1955	Diane	800,000	24.8%	9,911	NOAA	696,402	NC	1
1955	Ione			4,500	PCS	362,090	NC	3
1956	Flossy			3,700	PCS	275,001	LA	2

Exhibit 3
Sheet 3

Hurricane Loss Estimates
Continental U.S. 1900 - 1999

Dollars in Thousands

		Total Estimated Actual Loss at Time of Event						
Year	Hurricane Number/ Name	Economic	Insurance Utilization	Insured	Source	Insured Loss Normalized To 2000	Max Loss State/Region	Max Category
1957	Audrey			$ 32,000	PCS	$ 1,176,396	LA	4
1959	Cindy	$ 500	27.8%	139	NOAA	5,717	SC	1
1959	Debra			7,900	PCS	393,073	TX - No	1
1959	Gracie			13,000	PCS	605,316	SC	3
1960	Donna			91,000	PCS	4,709,959	FL - SE	4
1960	Ethel	1,000	28.6%	286	NOAA	11,837	MS	1
1961	Carla			100,000	PCS	3,476,218	TX - No, Ce	4
1963	Cindy			154	PCS	3,954	TX - No	1
1964	Cleo			67,200	PCS	3,746,855	FL - SE	2
1964	Dora			12,000	PCS	403,169	FL - NE	2
1964	Hilda			23,000	PCS	596,026	LA	3
1964	Isabel			2,000	PCS	122,518	FL - SE	2
1965	Betsy			515,000	PCS	11,518,111	LA	3
1966	Alma			5,400	PCS	194,630	FL - SW	2
1966	Inez			596	PCS	16,208	FL - SE	1
1967	Beulah			34,800	PCS	888,088	TX - So	3
1968	Gladys			2,580	PCS	96,877	FL - SW	2
1969	Camille			166,000	PCS	2,949,789	MS	5
1969	Gerda	500	35.4%	177	NOAA	2,439	ME	1
1970	Celia			309,950	PCS	4,568,366	TX - Ce, So	3
1971	Fern			1,380	PCS	18,825	TX - No, Ce	2
1971	Edith			5,730	PCS	71,158	LA	1
1971	Ginger			2,000	PCS	31,447	NC	1
1972	Agnes			101,948	PCS	956,927	PA	1
1974	Carmen			14,721	PCS	118,642	LA	3
1975	Eloise			77,868	PCS	783,072	FL - NW	3
1976	Belle			22,697	PCS	127,951	NY	1
1977	Babe			2,000	PCS	11,414	LA	1
1979	Bob	20,000	42.9%	8,582	NOAA	34,636	LA	1
1979	David			86,990	PCS	547,711	FL - NE	2
1979	Frederic			742,044	PCS	3,686,521	AL	3
1980	Allen			57,611	PCS	283,869	TX - So	3
1983	Alicia			1,274,500	AIRAC	3,912,101	TX - No	3
1984	Diana			36,000	AIRAC	133,682	NC	3
1985	Bob			10,000	AIRAC	29,419	SC	1
1985	Danny			24,500	AIRAC	58,548	LA	1
1985	Elena			622,000	AIRAC	1,650,468	MS	3
1985	Gloria			618,300	AIRAC	1,435,127	NY	3
1985	Juan			78,500	AIRAC	192,283	LA	1
1985	Kate			67,800	AIRAC	189,781	FL -NW	2
1986	Bonnie			21,269	PCS	42,825	TX - No	1
1986	Charley			7,000	PCS	19,357	NC	1
1987	Floyd	500	49.0%	245	NOAA	502	FL - SW	1
1988	Florence			10,000	PCS	19,065	LA	1
1989	Chantal			40,000	PCS	69,972	TX - No	1
1989	Hugo			2,955,000	PCS	5,529,261	SC	4
1989	Jerry			35,000	PCS	63,918	TX - No	1
1991	Bob			610,000	PCS	923,918	MA	2
1992	Andrew			16,600,000	FL Dept	24,486,691	FL - SE	4
1993	Emily			30,000	PCS	47,299	NC	3
1995	Erin			375,000	PCS	484,223	FL - NW, NE	1
1995	Opal			1,990,000	PCS	2,584,891	FL - NW	3

Exhibit 3
Sheet 4

Hurricane Loss Estimates
Continental U.S. 1900 - 1999

Dollars in Thousands

Year	Hurricane Number/ Name	Total Estimated Actual Loss at Time of Event: Economic	Insurance Utilization	Insured	Source	Insured Loss Normalized To 2000	Max Loss State/Region	Max Category
1996	Bertha			$ 135,000	PCS	$ 169,071	NC	2
1996	Fran			1,535,000	PCS	1,910,703	NC	3
1997	Danny			35,000	PCS	41,277	AL	1
1998	Bonnie			360,000	PCS	400,501	NC	2
1998	Earl			18,000	PCS	19,929	FL - NW	1
1998	Georges			1,155,000	PCS	1,270,333	FL - SW	2
1999	Bret			30,000	PCS	31,388	TX - So	3
1999	Floyd			1,875,000	PCS	1,979,274	NC	2

#	%	Category	Insured	Sum	%	Average
62	37.8%	1		7,573,283	2.6%	$ 122,150
38	23.2%	2		24,289,360	8.5%	639,194
47	28.7%	3		93,362,199	32.5%	1,986,430
15	9.1%	4		157,930,884	55.0%	10,528,726
2	1.2%	5		4,141,174	1.4%	2,070,587
164	100.0%	All	33,586,399	287,296,900		1,751,810

#	%	Decade	Sum	%	Average
15	9.1%	Aughts	31,942,476	11.1%	2,129,498
20	12.2%	Teens	36,264,818	12.6%	1,813,241
15	9.1%	Twenties	64,400,759	22.4%	4,293,384
17	10.4%	Thirties	16,689,841	5.8%	981,755
23	14.0%	Forties	27,116,547	9.4%	1,178,980
18	11.0%	Fifties	23,209,438	8.1%	1,289,413
15	9.1%	Sixties	28,736,676	10.0%	1,915,778
12	7.3%	Seventies	10,956,670	3.8%	913,056
16	9.8%	Eighties	13,630,178	4.7%	851,886
13	7.9%	Nineties	34,349,498	12.0%	2,642,269
164		All	287,296,900		1,751,810

Notes:

Where based on NOAA, insured loss equals economic loss times insurance utilization factor times flood adjustment factor. Only the following storms, which had unusual amounts of uninsured flood damage, were reduced to reflect flood: 1900 #1 (50%), 1915 #2 (75%), 1916 #1 (50%), 1955 Diane (5%).

Economic losses for smaller events estimated judgmentally.

PCS losses exclude the following states and territories, which were excluded from the normalization model:

1975 Eloise	PA, PR
1979 David	PR, VI, VA to MA
1979 Frederic	KY, NY, OH, PA, WV
1980 Allen	PR, VI
1989 Hugo	PR, VI
1995 Opal	NC, SC, TN
1996 Fran	PA, OH
1997 Danny	NC, SC
1998 Georges	PR, VI
1999 Floyd	PA, RI

Exhibit 4
Sheet 1

Normalized Hurricane Loss - Annual Aggregate Severity Distributions by State

Dollars in Thousands

	Normalized Actual 20th Century Return Period (Years)						Expected	% of
State	100	50	25	20	10	5	Annual	Total
Texas	$ 16,357,807	$ 16,044,802	$ 4,568,366	$ 3,912,101	$ 959,320	$ 133,890	$ 615,179	21.4%
Louisiana	10,426,919	1,642,437	1,115,135	723,002	343,527	30,640	195,641	6.8%
Mississippi	2,490,730	1,337,271	799,333	735,718	159,861	3,683	77,431	2.7%
Alabama	2,406,881	1,363,217	385,039	379,566	31,137	1,335	61,380	2.1%
Florida	49,744,060	23,763,689	7,976,601	5,837,485	3,052,795	910,060	1,422,764	49.5%
Georgia	429,105	176,122	101,460	73,375	15,783	1,094	11,487	0.4%
South Carolina	4,140,037	606,128	244,375	220,535	40,168	5,947	61,660	2.1%
North Carolina	1,943,528	1,768,044	1,399,847	1,371,862	267,909	23,152	109,399	3.8%
Virginia	2,188,909	872,795	112,753	104,579	33,871	842	38,253	1.3%
Maryland	834,038	484,365	53,170	48,076	5,340	-	16,951	0.6%
Delaware	341,019	26,476	14,979	14,200	365	-	4,360	0.2%
New Jersey	980,301	600,714	99,297	92,297	32,234	-	22,166	0.8%
New York	3,082,156	1,490,510	208,076	183,374	36,439	-	61,227	2.1%
Connecticut	4,095,213	504,385	151,939	76,484	50	-	50,944	1.8%
Rhode Island	1,322,697	416,528	160,166	134,081	-	-	24,819	0.9%
Massachusetts	2,904,903	1,484,027	456,272	367,780	924	-	63,812	2.2%
New Hampshire	412,611	159,311	11,635	10,464	-	-	6,178	0.2%
Maine	285,940	56,837	18,511	17,402	-	-	4,175	0.1%
Total All States	51,789,586	24,486,691	16,485,683	15,106,320	9,373,159	3,555,627	2,872,969	

Note: Return period loss based on distribution by state of normalized losses in Exhibit 3, e.g., 100 year return is the worst year in the 20th century, 50 year return is the second worst year, 25 year return is the 4th worst year, etc. Not to be confused with probabilistic return period distributions and expected losses based on catastrophe models, which are intended to reflect longer term probabilities.

Exhibit 4
Sheet 2

Normalized Hurricane Loss - Maximum Single Occurrence Severity Distributions by State

Dollars in Thousands

	Normalized Actual 20th Century Return Period (Years)						
State	100	50	25	20	10	5	100 Year Event
Texas	$ 16,357,807	$ 16,044,802	$ 4,568,366	$ 3,912,101	$ 959,320	$ 69,972	1900 - 1 ("Isaac's")
Louisiana	10,426,919	1,540,864	1,115,135	723,002	343,527	28,513	1965 - Betsy
Mississippi	2,490,730	1,331,575	793,954	735,718	159,861	3,683	1969 - Camille
Alabama	2,406,138	1,363,217	353,807	218,189	31,137	1,335	1979 - Frederick
Florida	47,989,146	23,763,689	7,976,601	5,837,485	2,853,627	894,836	1926 - 6
Georgia	429,105	176,122	101,460	73,375	15,783	1,094	1995 - Opal
South Carolina	4,140,037	605,316	244,375	220,535	37,008	5,947	1989 - Hugo
North Carolina	1,943,528	1,641,766	1,371,862	641,628	267,909	23,152	1954 - Hazel
Virginia	2,188,909	854,007	112,753	104,579	33,871	842	1954 - Hazel
Maryland	834,038	484,106	53,170	48,076	5,340	-	1954 - Hazel
Delaware	341,019	26,476	14,979	14,200	365	-	1954 - Hazel
New Jersey	600,714	579,055	99,297	92,297	32,234	-	1938 - 4 or 1954 - Hazel
New York	3,082,156	1,077,727	208,076	183,374	36,439	-	1938 - 4 ("Great New England")
Connecticut	4,095,213	351,008	151,939	76,484	50	-	1938 - 4 ("Great New England")
Rhode Island	1,183,942	416,528	160,166	134,081	-	-	1954 - Carol
Massachusetts	2,655,844	1,484,027	456,272	367,780	924	-	1954 - Carol
New Hampshire	332,968	159,311	11,635	10,464	-	-	1954 - Carol
Maine	263,178	56,837	18,511	17,402	-	-	1954 - Carol
Total All States	49,728,840	24,486,691	16,146,375	11,518,111	7,976,601	3,476,218	

Note: Return period loss based on distribution by state of the largest normalized loss per year in Exhibit 3, e.g., 100 year return is the worst event, 50 year return is the second worst event, 25 year return is the 4th worst event, etc. Not to be confused with probabilistic return period distributions and expected losses based on catastrophe models, which are intended to reflect longer term probabilities.

Exhibit 5

Normalized Hurricane Loss - Annual Aggregate Severity Distributions by State and County
Counties with Significant Annual Expected Losses

Dollars in Thousands

		Estimated 2000	Normalized Actual 20th Century Return Period (Years)							Expected
State	County	Housing Units	100	50	25	20	10	5	Expected Annual	Loss Per Unit ($'s)
TX										
	Harris	1,305,351	$9,953,674	$8,841,048	$729,077	$560,265	$199,602	$0	$245,595	$188
	Galveston	110,157	4,506,461	4,084,453	360,805	315,733	44,502	1,106	104,432	948
	Nueces	122,333	7,287,137	2,001,912	90,356	53,950	36,982	0	98,660	806
	Brazoria	88,261	1,359,509	581,793	166,175	164,674	28,757	434	33,046	374
	Fort Bend	121,367	911,594	401,431	160,493	153,787	14,463	0	23,965	197
	Cameron	114,432	647,510	513,497	68,357	32,195	3,878	0	14,581	127
	Aransas	14,188	1,203,723	114,140	6,721	4,802	1,624	0	14,044	990
	San Patricio	26,640	1,032,527	136,714	6,968	5,220	3,636	0	12,619	474
	Montgomery	114,584	285,815	244,840	53,763	22,594	3,909	0	7,953	69
	Hidalgo	184,668	555,041	119,872	14,585	5,975	0	0	7,720	42
	Jefferson	97,558	261,334	165,980	33,504	21,097	7,430	32	6,103	63
	Matagorda	18,329	179,112	141,720	42,226	9,220	1,892	206	4,539	248
	Chambers	9,305	145,296	127,939	8,388	4,940	1,430	11	3,147	338
	Victoria	31,792	268,874	14,153	5,013	1,338	355	0	3,067	96
FL										
	Dade	860,587	24,841,690	21,503,754	2,448,916	1,154,922	528,163	32,634	594,201	690
	Broward	784,873	8,274,310	1,837,931	1,275,267	1,250,347	432,580	30,674	188,435	240
	Palm Beach	580,029	2,613,939	2,449,415	1,278,092	874,908	186,600	30,599	119,848	207
	Monroe	48,610	3,285,189	1,306,132	815,359	659,162	93,993	8,586	86,746	1,785
	Lee	232,004	4,333,589	1,174,856	282,775	278,928	47,403	14,434	75,937	327
	Escambia	122,238	1,242,614	537,338	243,515	86,124	8,999	156	26,799	219
	Brevard	228,560	805,310	688,639	202,758	173,427	23,231	2,025	25,084	110
	Collier	134,052	1,510,837	345,577	110,492	68,745	12,317	4,488	25,022	187
	Sarasota	174,066	1,157,395	723,028	112,817	51,022	23,990	5,187	24,846	143
	Pinellas	470,889	603,486	470,479	152,418	95,421	58,754	9,286	23,269	49
	Santa Rosa	52,623	961,706	639,907	150,955	83,197	8,161	250	22,866	435
	St. Lucie	94,666	1,110,664	376,664	115,185	76,408	24,309	1,799	21,996	232
	Hillsborough	413,122	749,675	222,368	134,788	95,736	26,053	4,100	16,790	41
	Okaloosa	79,064	632,113	336,647	121,265	60,763	5,794	336	14,755	187
	Martin	64,667	619,485	272,745	117,000	74,602	10,303	1,420	14,627	226
	Manatee	133,772	483,954	468,404	71,797	39,658	23,189	3,284	13,879	104
	Volusia	216,688	314,543	278,535	148,743	137,068	14,648	1,118	13,635	63
	Orange	339,869	411,441	196,923	134,578	122,244	20,628	343	13,610	40
	Polk	213,034	375,193	365,058	124,589	109,153	16,023	1,041	13,420	63
	Indian River	52,411	562,726	174,576	40,527	37,628	12,896	509	11,084	211
	Charlotte	84,296	568,944	270,309	22,544	16,893	6,665	761	10,038	119
	Pasco	175,854	219,943	162,509	47,060	30,902	11,942	1,696	6,880	39
	Lake	106,250	186,706	179,379	44,272	42,158	8,788	301	6,538	62
	Seminole	152,097	145,588	95,484	61,216	55,408	6,372	0	5,571	37
	Duval	317,548	232,279	84,687	46,432	28,001	5,734	0	5,544	17
	Bay	81,598	264,066	100,921	36,975	17,167	5,810	0	5,423	66
	Osceola	70,504	148,485	65,616	36,843	23,752	6,872	219	4,080	58
	Marion	124,315	131,971	107,128	23,137	22,395	8,516	243	4,071	33
	Highlands	46,304	60,603	52,898	25,421	22,991	2,042	236	2,745	59

Note: Return period loss based on distribution by state and county of normalized losses in Exhibit 3, e.g., 100 year return is the worst year in the 20th century, 50 year return is the second worst year, 25 year return is the 4th worst year, etc. Not to be confused with probabilistic return period distributions and expected losses based on catastrophe models, which are intended to reflect longer term probabilities. Expected loss per unit compares expected annual losses (personal, commercial, and auto) with residential - only housing units, i.e., it is intended as a relative measure of cost per unit of exposure but not as a measure of residential costs per unit.

Exhibit 6
Sheet 1

Comparison of Actual vs. Modeled Hurricane Experience

Number of Landfalling Storms per Century

	Actual 20th Century			Model T		
Category	CW	TX	FL	CW	TX	FL
1	63	12	17	62.0	11.0	16.5
2	36	8	15	37.5	8.5	15.0
3	48	10	16	46.0	9.5	17.0
4	15	6	5	16.0	5.0	6.0
5	2	0	1	2.5	0.5	1.0
All	164	36	54	164.0	34.5	55.5

Estimated Annual Aggregate Insured Loss ($000)

	Normalized 20th Century			Model T		
Category	CW	TX	FL	CW	TX	FL
1	$ 75,733	$ 9,146	$ 44,648	$ 59,199	$ 5,176	$ 26,473
2	242,894	22,175	134,857	300,721	34,207	143,086
3	933,622	131,962	329,344	852,477	88,322	391,428
4	1,579,309	451,897	902,001	1,262,920	186,123	714,092
5	41,412	-	11,914	403,634	65,421	191,347
Expected	2,872,969	615,179	1,422,764	2,878,951	379,250	1,466,427

Estimated Annual Aggregate Insured Loss ($000)

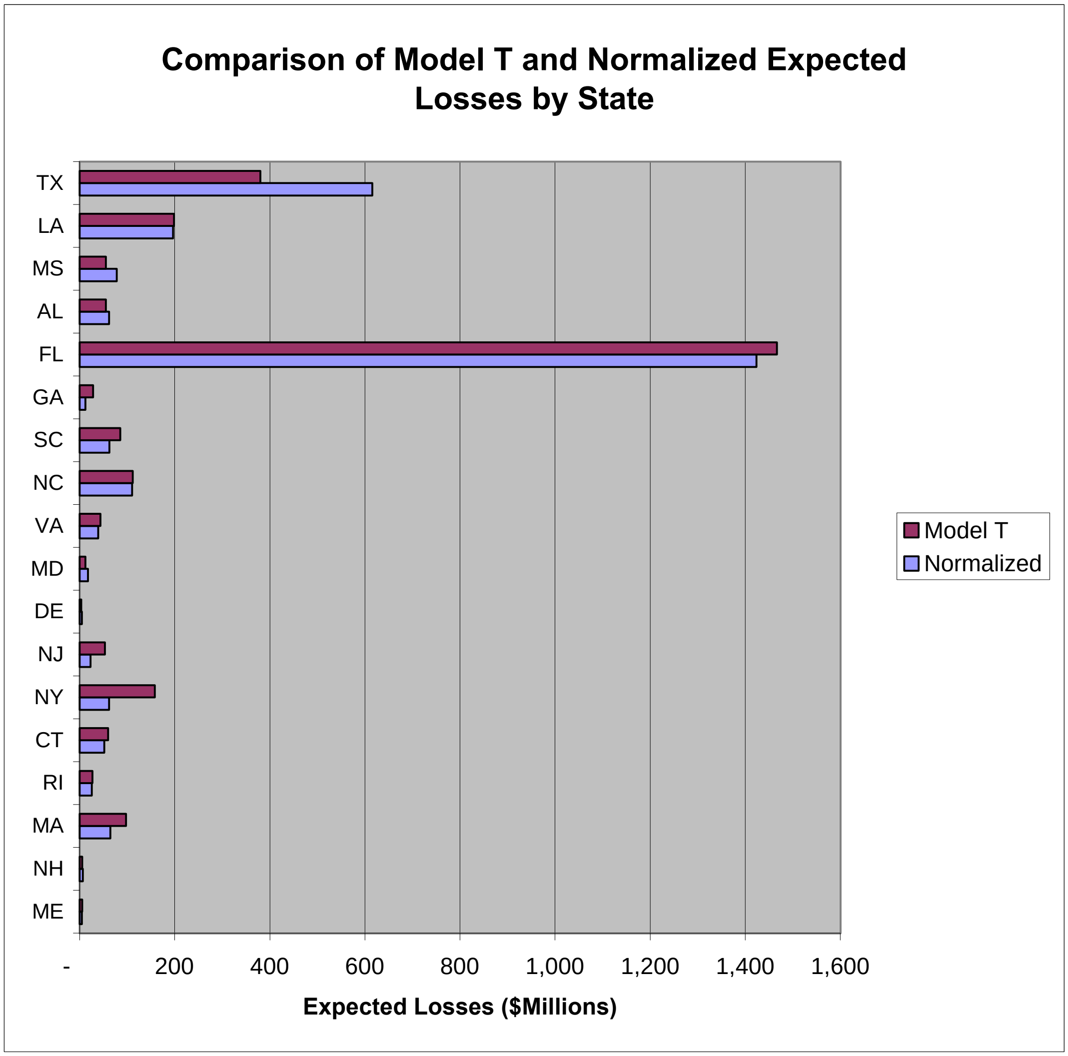
Return	Normalized 20th Century			Model T		
Period (Yrs)	CW	TX	FL	CW	TX	FL
5	$ 3,555,627	$ 133,890	$ 910,060	$ 3,569,742	$ 126,796	$ 954,030
10	9,373,159	959,320	3,052,795	6,917,383	684,396	3,206,555
20	15,106,320	3,912,101	5,837,485	11,780,896	2,032,334	7,702,533
25	16,485,683	4,568,366	7,976,601	14,687,232	2,821,885	10,343,645
50	24,486,691	16,044,802	23,763,689	21,710,120	5,061,653	17,296,870
100	51,789,586	16,357,807	49,744,060	33,133,590	8,331,148	28,926,913
Expected	2,872,969	615,179	1,422,764	2,878,951	379,250	1,466,427

Notes: Countrywide (CW) normalized figures based on continental U.S. from Exhibits 3 and 4.
Texas and Florida actual frequencies from Exhibit 1.
Texas and Florida normalized damages from Exhibit 4 and underlying data.
Model T is a hypothetical probabilistic hurricane model

Exhibit 6
Sheet 2

Comparison of Actual vs. Modeled Hurricane Expected Losses by State

State	Annual Expected Losses ($000) Normalized Actual	Model T	Model T Difference
Texas	$ 615,179	$ 379,250	-38%
Louisiana	195,641	197,501	1%
Mississippi	77,431	54,460	-30%
Alabama	61,380	54,522	-11%
Florida	1,422,764	1,466,427	3%
Georgia	11,487	27,849	142%
South Carolina	61,660	84,864	38%
North Carolina	109,399	110,872	1%
Virginia	38,253	43,274	13%
Maryland	16,951	11,685	-31%
Delaware	4,360	2,766	-37%
New Jersey	22,166	52,633	137%
New York	61,227	157,509	157%
Connecticut	50,944	59,280	16%
Rhode Island	24,819	26,220	6%
Massachusetts	63,812	96,552	51%
New Hampshire	6,178	4,721	-24%
Maine	4,175	4,830	16%
All States	2,872,969	2,878,951	0%


Comparison of Model T and Normalized Expected Losses by State

Notes: Normalized figures from Exhibit 4, Sheet 1
Model T is a hypothetical probabilistic hurricane model

Exhibit 6
Sheet 3

Comparison of Actual vs. Modeled Hurricane Losses

Top 50 Historical Normalized Events

Rank	Year	Number/ Name	Normalized	Model T	Max Loss State/Region	Max Category
1	1926	6	49,728,840	44,000,000	FL - SE	4
2	1992	Andrew	24,486,691	24,900,000	FL - SE	4
3	1900	1	16,485,683	11,900,000	TX - No	4
4	1915	2	16,146,375	9,800,000	TX - No	4
5	1965	Betsy	11,518,111	12,900,000	LA	3
6	1919	2	10,009,409	4,800,000	FL - SW	4
7	1938	4	9,965,606	12,800,000	CT	3
8	1928	4	9,816,472	16,700,000	FL - SE	4
9	1954	Hazel	8,196,810	6,700,000	NC	4
10	1909	9	7,976,601	3,400,000	FL - SE	3
11	1954	Carol	6,265,912	5,600,000	MA	3
12	1944	11	5,855,343	9,700,000	FL -SW	3
13	1989	Hugo	5,529,261	5,900,000	SC	4
14	1947	4	5,432,151	17,600,000	FL - SE	4
15	1960	Donna	4,709,959	8,800,000	FL - SE	4
16	1970	Celia	4,568,366	4,400,000	TX - Ce, So	3
17	1983	Alicia	3,912,101	2,800,000	TX - No	3
18	1945	9	3,762,550	6,600,000	FL -SE	3
19	1964	Cleo	3,746,855	2,900,000	FL - SE	2
20	1979	Frederic	3,686,521	2,100,000	AL	3
21	1961	Carla	3,476,218	2,600,000	TX - No, Ce	4
22	1916	1	3,096,434	2,300,000	MS	3
23	1969	Camille	2,949,789	3,300,000	MS	5
24	1950	King	2,853,627	7,500,000	FL - SE	3
25	1910	4	2,735,157	3,100,000	FL - SW	3
26	1949	2	2,728,296	6,700,000	FL - SE	3
27	1995	Opal	2,584,891	2,400,000	FL - NW	3
28	1903	3	2,124,106	2,600,000	FL - SE	2
29	1944	7	2,087,738	4,500,000	MA	3
30	1999	Floyd	1,979,274	2,000,000	NC	2
31	1996	Fran	1,910,703	2,100,000	NC	3
32	1926	1	1,755,434	2,700,000	FL - NE	2
33	1915	5	1,709,809	2,700,000	LA	4
34	1985	Elena	1,650,468	1,300,000	MS	3
35	1921	6	1,624,995	5,400,000	FL - SW	3
36	1947	8	1,460,391	1,200,000	FL - SE	2
37	1985	Gloria	1,435,127	1,900,000	NY	3
38	1955	Connie	1,378,549	1,700,000	MD	3
39	1935	6	1,371,030	1,500,000	FL - SE	2
40	1933	8	1,356,989	1,300,000	VA	2
41	1998	Georges	1,270,333	1,300,000	FL - SW	2
42	1935	2	1,191,386	2,400,000	FL - SW	5
43	1957	Audrey	1,176,396	1,000,000	LA	4
44	1933	12	1,163,819	3,900,000	FL -SE	3
45	1909	3	1,119,560	1,600,000	TX - No	3
46	1942	2	1,028,039	500,000	TX - No, Ce	3
47	1943	1	970,828	700,000	TX - No	2
48	1972	Agnes	956,927	400,000	PA	1
49	1941	5	942,310	8,100,000	FL - SE	2
50	1991	Bob	923,918	1,300,000	MA	2
			264,812,155	294,300,000		

Notes: Normalized figures from Exhibit 3
Model T is a hypothetical hurricane model

Appendix A
Exhibit 1

Hurricanes Affecting the Bermuda, Hawaii, Puerto Rico and USVI 1900-1999

			Category and Key Islands Affected								
				Hawaiian Islands				US Virgin Islands			
Year	Number/ Name	Date of First Landfall	Bermuda	Hawaii	Kauai	Oahu	Puerto Rico	St. Thomas	St. Croix	PR or USVI	US Landfall States Affected and Category
1900	4	17-Sep	1								None
1903	6	28-Sep	1								None
1915	3	03-Sep	1								None
1916	10	23-Sep	1								None
1918	4	04-Sep	1								None
1921	3	15-Sep	1								None
1922	2	21-Sep	2								None
1926	10	22-Oct	3								None
1939	4	16-Oct	3								None
1947	9	20-Oct	2								None
1948	6	13-Sep	2								None
1948	8	07-Oct	2								FLSE 2
1953	Edna	17-Sep	2								None
1963	Arlene	09-Aug	1								None
1987	Emily	24-Sep	2								None
1989	Dean	06-Aug	1								None
1999	Gert	21-Sep	1								None
1950	Hiki	15-Aug			1						
1957	Nina	02-Dec			1						
1959	Dot	06-Aug			2						
1982	Iwa	23-Nov			1	1					
1992	Iniki	11-Sep			4						
1916	5/San Hipolito	22-Aug					1	2	2	2	None
1916	12							2	1	2	None
1926	1/San Liborio	23-Jul					1			1	FLNE 2
1928	4/San Felipe	13-Sep					5		5	5	FLSE 4, FLNE 2, GA 1, SC 1
1930	2	02-Sep					1			1	None
1931	6/San Nicolas	10-Sep					2	2	1	2	None
1932	7/San Ciprian	26-Sep					2	2	1	2	None
1956	Santo Clara (Betsy)	12-Aug					1			1	None
1960	Donna	05-Sep						1		1	FLSW 4, NC 3, NY 3
1989	Hugo	18-Sep					4	3	4	4	SC 4
1995	Marilyn	16-Sep						2	2	2	None
1996	Bertha	08-Jul						1		1	NC 2
1996	Hortense	10-Sep					1			1	None
1998	Georges	21-Sep					2	1	2	2	FLSW 2, MS 2
1999	Lenny	17-Nov							1	1	None
	Category 1		9	0	3	1	5	3	4	7	
	Category 2		6	0	1	0	3	5	3	6	
	Category 3		2	0	0	0	0	1	0	0	
	Category 4		0	0	1	0	1	0	1	1	
	Category 5		0	0	0	0	1	0	1	1	
	Total		17	0	5	1	10	9	9	15	

Note: Category designations, according to Saffir/Simpson Hurricane Scale, based on estimated sustained winds over land reflecting authors' judgment based on review of:

- NOAA summary reports and best track files (www.nhc.noaa.gov/pastall.html)
- Neumann (Newmann, Jarvinen, McAdie and Elms, 1993, p. 31)
- Hebert (Hebert, Jarrell and Mayfield, 1996, Table 14)
- Tucker (Tucker, 1995)

No hurricanes have affected the west coast of the U.S. during the 20th century. According to the National Weather Service office in Oxnard, California, two storms are recognized as having produced tropical storm conditions over land:

- September 25, 1939 in Southern California (Long Beach area)
- October 6, 1972 in Arizona (remnants of Hurricane Joanne)

Appendix A
Exhibit 2

Hurricanes Affecting the Bermuda, Hawaii, Puerto Rico and USVI 1900-1999

Estimated Damage at Time of Event
Dollars in Thousands

Year	Number/ Name	Estimated Damage Economic	Estimated Damage Insured	Source
Bermuda				
1900	4	Unk		
1903	6	Unk		
1915	3	Unk		
1916	10	Unk		
1918	4	Unk		
1921	3	Unk		
1922	2	Unk		
1926	10	Unk		
1939	4	Unk		
1947	9	Unk		
1948	6	Unk		
1948	8	Unk		
1953	Edna	Unk		
1963	Arlene		75	Tucker
1987	Emily		35,000	NOAA
1989	Dean		5,000	NOAA
1999	Gert		Unk	
Hawaii				
1950	Hiki	Unk		
1957	Nina	200		Hebert
1959	Dot	6,000		Hebert
1982	Iwa		137,000	PCS
1992	Iniki		1,906,000	PCS

Year	Number/ Name	Economic	Insured PR	Insured USVI	Source
Puerto Rico and USVI					
1916	5/San Hipolito	1,000			Hebert
1916	12	Unk			
1926	1/San Liborio	5,000			Hebert
1928	4/San Felipe	85,000			Hebert
1930	2	Unk			
1931	6/San Nicolas	200			Hebert
1932	7/San Ciprian	30,000			Hebert
1956	Santo Clara (Betsy)	40,000	10,000		PCS
1960	Donna	Unk			Hebert
1989	Hugo		440,000	800,000	PCS
1995	Marilyn		75,000	800,000	PCS
1996	Bertha			Unk	
1996	Hortense		150,000		PCS
1998	Georges		1,750,000	50,000	PCS
1999	Lenny			Unk	

Appendix B
Exhibit 1

Historical Indices Used in Normalization Model
Annual Growth Rates

Year	Implicit Price Deflator	Net Stock of FRTW	National Housing Units	National Population	Insurance Utilization
1901	3.5%	2.5%	1.9%	1.9%	2.2%
1902	3.5%	2.5%	1.9%	1.9%	2.2%
1903	3.5%	2.5%	1.9%	1.9%	2.1%
1904	3.5%	2.5%	1.9%	1.9%	2.1%
1905	3.5%	2.5%	1.9%	1.9%	2.0%
1906	3.5%	2.5%	1.9%	1.9%	2.0%
1907	3.5%	2.5%	1.9%	1.9%	1.9%
1908	3.5%	2.5%	1.9%	1.9%	1.9%
1909	3.5%	2.5%	1.9%	1.9%	1.9%
1910	3.5%	2.5%	1.9%	1.9%	1.8%
1911	3.5%	2.5%	1.4%	1.4%	1.8%
1912	3.5%	2.5%	1.4%	1.4%	1.8%
1913	3.5%	2.5%	1.4%	1.4%	1.7%
1914	3.5%	2.5%	1.4%	1.4%	1.7%
1915	3.5%	2.5%	1.4%	1.4%	1.7%
1916	3.5%	2.5%	1.4%	1.4%	1.7%
1917	3.5%	2.5%	1.4%	1.4%	1.6%
1918	3.5%	2.5%	1.4%	1.4%	1.6%
1919	3.5%	2.5%	1.4%	1.4%	1.6%
1920	3.5%	2.5%	1.4%	1.4%	1.6%
1921	3.5%	2.5%	1.5%	1.5%	1.5%
1922	3.5%	2.5%	1.5%	1.5%	1.5%
1923	3.5%	2.5%	1.5%	1.5%	1.5%
1924	3.5%	2.5%	1.5%	1.5%	1.5%
1925	3.5%	2.5%	1.5%	1.5%	1.4%
1926	3.5%	4.1%	1.5%	1.5%	1.4%
1927	3.5%	3.6%	1.5%	1.5%	1.4%
1928	3.5%	3.2%	1.5%	1.5%	1.4%
1929	3.5%	3.2%	1.5%	1.5%	1.4%
1930	3.5%	1.7%	1.5%	1.5%	1.3%
1931	3.5%	0.4%	0.7%	0.7%	1.3%
1932	3.5%	-1.0%	0.7%	0.7%	1.3%
1933	3.5%	-1.3%	0.7%	0.7%	1.3%
1934	3.5%	-0.6%	0.7%	0.7%	1.3%
1935	3.5%	0.2%	0.7%	0.7%	1.3%
1936	3.5%	1.5%	0.7%	0.7%	1.2%
1937	3.5%	1.8%	0.7%	0.7%	1.2%
1938	3.5%	0.9%	0.7%	0.7%	1.2%
1939	3.5%	1.7%	0.7%	0.7%	1.2%
1940	3.5%	2.1%	0.7%	0.7%	1.2%
1941	3.5%	3.7%	2.1%	1.4%	1.2%
1942	3.5%	5.4%	2.1%	1.4%	1.2%
1943	3.5%	5.8%	2.1%	1.4%	1.1%
1944	3.5%	4.6%	2.1%	1.4%	1.1%
1945	3.5%	2.1%	2.1%	1.4%	1.1%
1946	3.5%	0.4%	2.1%	1.4%	1.1%
1947	3.5%	1.4%	2.1%	1.4%	1.1%
1948	3.5%	2.1%	2.1%	1.4%	1.1%
1949	3.5%	2.6%	2.1%	1.4%	1.1%
1950	3.5%	3.7%	2.1%	1.4%	1.1%
1951	5.5%	4.0%	2.4%	1.7%	3.6%
1952	1.4%	3.8%	2.4%	1.7%	3.5%
1953	0.9%	4.2%	2.4%	1.7%	3.4%
1954	0.9%	3.7%	2.4%	1.7%	3.2%
1955	2.7%	4.3%	2.4%	1.7%	3.1%
1956	3.2%	3.7%	2.4%	1.7%	3.0%
1957	2.8%	3.4%	2.4%	1.7%	3.0%
1958	2.7%	2.8%	2.4%	1.7%	2.9%
1959	0.8%	3.6%	2.4%	1.7%	2.8%
1960	1.6%	3.3%	2.4%	1.7%	2.7%
1961	1.0%	3.1%	1.6%	1.3%	2.6%
1962	1.3%	3.5%	1.6%	1.3%	2.6%
1963	1.5%	3.7%	1.6%	1.3%	2.5%
1964	1.4%	4.1%	1.6%	1.3%	2.5%
1965	2.2%	4.4%	1.6%	1.3%	2.4%
1966	3.4%	4.5%	1.6%	1.3%	2.3%
1967	3.4%	4.0%	1.6%	1.3%	2.3%
1968	4.5%	4.1%	1.6%	1.3%	2.2%
1969	4.9%	3.9%	1.6%	1.3%	2.2%
1970	5.1%	3.2%	1.6%	1.3%	2.1%
1971	4.9%	3.3%	2.6%	1.1%	2.1%
1972	4.4%	4.0%	2.6%	1.1%	2.0%
1973	6.9%	3.9%	2.6%	1.1%	2.0%
1974	10.6%	3.0%	2.6%	1.1%	2.0%
1975	7.6%	2.2%	2.6%	1.1%	1.9%
1976	5.5%	2.6%	2.6%	1.1%	1.9%
1977	6.7%	3.1%	2.6%	1.1%	1.9%
1978	7.7%	3.5%	2.6%	1.1%	1.8%
1979	8.7%	3.4%	2.6%	1.1%	1.8%
1980	10.0%	2.5%	2.6%	1.1%	1.8%
1981	8.4%	2.4%	1.5%	0.9%	1.7%
1982	5.2%	1.8%	1.5%	0.9%	1.7%
1983	3.9%	2.2%	1.5%	0.9%	1.7%
1984	3.5%	3.1%	1.5%	0.9%	1.6%
1985	3.4%	3.3%	1.5%	0.9%	1.6%
1986	2.5%	3.2%	1.5%	0.9%	1.6%
1987	3.2%	3.0%	1.5%	0.9%	1.6%
1988	4.0%	2.9%	1.5%	0.9%	1.5%
1989	3.9%	2.6%	1.5%	0.9%	1.5%
1990	4.6%	2.3%	1.5%	0.9%	1.5%
1991	3.4%	1.6%	1.2%	1.0%	1.5%
1992	2.6%	1.7%	1.2%	1.0%	1.5%
1993	2.6%	2.0%	1.2%	1.0%	1.4%
1994	2.5%	2.2%	1.2%	1.0%	1.4%
1995	2.1%	2.5%	1.2%	1.0%	1.4%
1996	1.8%	2.7%	1.2%	1.0%	0.0%
1997	1.7%	2.7%	1.2%	1.0%	0.0%
1998	1.2%	2.7%	1.2%	1.0%	0.0%
1999	1.5%	2.7%	1.2%	1.0%	0.0%
2000	2.0%	2.7%	1.2%	1.0%	0.0%

Notes: Implicit price deflator available back to 1950; 3.5% trend assumed for 1950 and prior
FRTW is fixed reproducable tangible wealth, Department of Commerce, Bureau of Economic Analysis
 - Available back to 1925; 2.5% trend assumed for 1925 and prior
Housing units and population growth based on annual growth between each decennial census
Insurance utilization index based on linear trends from 1900 to 1950 and from 1950 to 1995
 - See text and graph on Appendix B, Exhibit 2 for further information

Appendix B
Exhibit 2

Industry Annual Insured Hurricane Losses as a Percentage of Total Damages (Insurance Utilization Ratio - Actual vs Selected)